TRANSLATION NO. 1540

DATE: 30 Sept 1965

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DEPARTMENT OF THE ARMY
Fort Detrick
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The results of the research on the NPK content in hemp leaves during different periods of development are shown in Table 1.

Table 1

Effect of Simazine and Atrazine on the Uptake of Nitrogen, Phosphorous, and Potassium in Hemp Plants (average for 1961 -- 1963)

Variants*		Content of Nitrogen, Phosphorous, and Potassium in Hemp Leaves, % of Air-Dried Substance								
		Nitrogen (N)			Phosphorous (P_2O_5)			Potassium (K_2O)		
		Three Pairs of Leaves	Mass Budding	Maturing of Staminate Hemp	Three Pairs of Leaves	Mass Budding	Maturing of Staminate Hemp	Three Pairs of Leaves	Mass Budding	Maturing of Staminate Hemp
Control		4,47	3,88	2,45	0,97	0,70	0,98	1,64	0,57	1,42
Simazine	0,5	4,35	3,70	2,44	0,96	0,71	0,97	1,58	0,55	1,40
"	1,0	4,40	3,89	2,44	0,96	0,74	0,98	1,62	0,61	1,44
"	1,5	4,45	3,81	2,48	0,97	0,72	0,96	1,60	0,60	1,42
"	2,0	4,32	3,65	2,50	0,94	0,67	0,97	1,52	0,60	1,29
"	2,5	4,12	3,49	2,32	0,90	0,66	0,88	1,40	0,47	1,25
"	3,0	4,03	3,32	2,24	0,81	0,65	0,75	1,40	0,47	1,20
Atrazine	0,5	4,38	3,75	2,40	0,97	0,69	0,99	1,63	0,58	1,43
"	1,0	4,32	3,84	2,42	0,98	0,71	0,98	1,62	0,55	1,42
"	1,5	4,42	3,72	2,53	0,95	0,70	0,95	1,58	0,55	1,40
"	2,0	4,25	3,45	2,38	0,93	0,68	0,95	1,52	0,46	1,35
"	2,5	4,18	3,28	2,34	0,82	0,65	0,87	1,38	0,45	1,25
"	3,0	4,05	3,22	2,23	0,80	0,64	0,78	1,33	0,44	1,19

* Here and later doses are given in active substances in kilograms per hectare.

From the data in Table 1 it is apparent that the herbicides in doses of up to 1.5 kilograms per hectare inclusive do not suppress the uptake of nitrogen into the hemp plants. The total nitrogen content during the course of the entire vegetative process was the same as it was in the leaves of the control variant.

When more than two kilograms per hectare are used the herbicides retarded the uptake of nitrogen.. The content of nitrogen in hemp leaves in the phase of three pairs of leaves was 3 -- 10% lower than in the control plants, and in subsequent phases of development (budding, maturing of staminate hemp) there was continued a diminution of the uptake of nitrogen into the hemp plant. It should be pointed out that the herbicides not only retarded the uptake of nitrogen into the hemp plants but suppressed the uptake of mineral hydrogen into the protein complex as a result of which there was observed a relative increase of non-proteic nitrogen and a lowering of proteic nitrogen.

From the data given in Table 2 it is apparent that the herbicides when applied in a dose of one kilogram per hectare did not have any ulterior effect on the content and ratio of proteic and non-proteic compounds of nitrogen. However, doses of 2 -- 3 kilograms noticeably lowered the content of protein and increased very slightly the content of non-proteic nitrogen. It is characteristic that the toxic effect of the indicated doses of herbicides on the protein exchange were more in evidence at the beginning of the vegetative process. It gradually leveled off somewhat but did not cease entirely.

Uptake of Nitrogen, Phosphorous, and Potassium in Hemp Plants When Simazine and Atrazine Are Applied

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Research conducted by the All-Union Scientific Research Institute for Bast Crops on chemical weeding of wide-row sown hemp has showed the feasibility of using such herbicides as simazine and atrazine during the pre-germination period.

The effectiveness of these herbicides differs depending on the doses used. Thus, with larger doses the destruction of weeds was more effective while at the same time the yield of hemp increased only up to a certain limit; beyond this limit the herbicides had a toxic effect on the hemp plants and this led to a lowering in the yield of fibre and seeds.

Considering that the productivity of plants and, consequently, the size of the yield, is closely related to root feeding in plants, it seemed of interest to study the uptake into hemp plants of the primary nutrient elements: nitrogen, phosphorous, and potassium in connection with the application of simazine and atrazine to hemp planting and the effect of these herbicides on the carbohydrate-protein exchange.

The uptake of the cited nutrient elements in hemp plants can be judged by their content in the leaves during various phases of development. For this reason in the field test where various doses of simazine and atrazine were used, there were selected average hemp leaves which were air-dried and then, after wet assaying using V. V. Pinevich's method, the nitrogen, phosphorous, and potassium content was determined. Ammonium nitrogen was distilled out in a micro-K'yel'dal' apparatus. The phosphorous content was determined by the calorimetric method (FEK-M, modification of Malyugin and Khrenova), and the potassium content was determined by a flame photometer.

In fresh hemp leaves the content of proteic nitrogen was determined using the Barshteyn method and the total nitrogen content was determined using the K'yel'dal' method. The content of reducing sugars and saccharose was determined by the Bertran method.

Table 2

Effect of Simazine and Atrazine on a Change in the Protein and Non-Protein Content of Nitrogen Compounds in Hemp Leaves (Field Test 1963)

Variants	Nitrogen Content in Milligrams per 100 Grams of Moist Leaves					
	Three Pairs of Leaves		Budding		Flowering	
	Non-Protein	Protein	Non-Protein	Protein	Non-Protein	Protein
Control	27,6	419,4	37,2	460,8	24,5	330,5
Simazine 1	26,8	412,7	37,6	461,4	24,6	329,4
" 2	34,6	397,4	42,8	432,2	24,9	335,1
" 3	60,5	342,5	49,9	392,1	30,2	303,8
Atrazine 1	27,7	319,8	37,1	456,6	24,4	327,6
" 2	37,4	387,6	37,3	417,7	24,3	323,7
" 3	58,9	346,1	48,8	383,2	30,1	302,9

It is generally known that nitrogen plays a huge role in the life of plants. It is part of protein and amino acids and also is an integral component of the structural elements of cells. A lowering of nitrogen in plants leads to extensive physiological changes.

Simazine and atrazine had an effect also on the uptake of phosphorous. In variants with the application of two kilograms of these herbicides per hectare and higher the uptake of phosphorous in hemp plants was retarded as a result of which the content in the leaves was less than was the case with the control variant. Thus, in the phase of three pairs of leaves the phosphorous content was 17% lower than in the control plants, in the budding phase 2--8% lower, and in the maturing [illegible] phase of the staminate hemp 23% lower than in the control plants. A phosphorous insufficiency in plants leads to the lowering of the synthetic activity of plants since phosphorous, when the nutrients are non-organic phosphates, enters into compounds in the roots with several organic acids. They also enter nuclear proteins and lipoids which make up the plasma of plant cells.

Simazine and atrazine in increased doses (2--3 kilograms per hectare) retard the intake of potassium in hemp plants during the entire period of vegetation. A calcium insufficiency in hemp acts negatively on the synthesis of carbohydrates and their movement in plants, the formation of chlorophyll, and the development of the bast-fibre layer.

From the material which has been presented it is apparent that simazine and atrazine in a dose of two kilograms per hectare and higher has a negative effect on the absorption of nitrogen, phosphorous, and potassium by hemp plants. However, these herbicides in smaller doses do not retard absorption of these elements.

The herbicidal effect of increased doses of simazine and atrazine was evidenced by the disruption of physiological processes in hemp plants.

Our research in determining the amount of carbohydrates in the leaves of hemp established that the indicated herbicides in certain doses suppress the synthesis of reducing sugars and facilitate the oxidizing of saccharose to monosugars.

Table 3

Effect of Simazine and Atrazine on the Synthesis of Sugar in Hemp Leaves
(Field Test 1963)

Variants	Sugar Content in Milligrams per 100 Grams of Raw Leaves					
	Three Pairs of Leaves		Budding		Flowering	
	Reducing	Saccharose	Reducing	Saccharose	Reducing	Saccharose
Control	712	276	1028	322	791	284
Simazine 1	680	284	1044	320	778	290
" 2	616	144	1042	308	742	282
" 3	432	152	914	286	742	268
Atrazine 1	704	252	1040	322	793	292
" 2	544	186	1004	316	767	278
" 3	410	192	952	268	744	262

As is apparent from the data in Table 3, herbicides in doses of one kilogram per hectare do not have any effect on the sugar content in hemp leaves. Only with doses of 2 -- 3 kilograms per hectare was there noticeable suppression of the synthesis of reducing sugars as a result of which there was a lowering in the saccharose content. In the phase of three pairs of leaves this suppression of the synthesis of reducing sugars was strongest and by the end of the flowering period it gradually decreased somewhat but did not disappear altogether.

With the introduction into live hemp leaves (preparatorily joined with carbohydrates by means of keeping them in darkness for 48 hours) of 0,02 M of a solution of glucose-fructose using A. L. Kursanov's method it was established that simazine and atrazine do not have any effect on the synthesis of saccharose. Over a period of three hours there was synthesized in the hemp leaves 61 -- 62% of the saccharose from the introduced monosugars, that is, as much saccharose as was synthesized in the control plants.

At the same time similar research with live hemp leaves into which saccharose had been introduced showed that simazine and atrazine strengthened the hydrolosis of the latter to monosugars. Thus, in the control variant hydrolysis of saccharose amounted to 32% and in the leaves into which together with saccharose there was introduced simazine and atrazine hydrolysis amounted to 43.5 -- 46.2%. This research gives evidence of the fact that herbicides in hemp plants along with suppressing synthesis of reducing sugars, strengthen the hydrolysis of saccharose. As a result of this the overall carbohydrate content decreases.

Considering the interdependence between breathing and the synthesis of organic compounds and also the existing connection between absorption saturation of mineral nutritive elements and the separation in the exchange to them of hydrogen H^+ and HCO_3^- in the process of breathing, it can be established that the cause of suppressed root feeding of hemp with 2 -- 3 kilograms per hectare of herbicides, apparently, lies in the slowing of the synthesis of organic compounds and in the lowering of the intensity of photosynthetic activity of chlorophyll. There are indications that simazine and atrazine block the synthesis of organic compounds [1 -- 3] as a result of the suppression by them of the photolytic splitting of water [4 -- 5] and the photosynthetic activity

of chlorophyll [6]. The hemp plants do not have enough organic compounds to satisfy completely the demands in them for meristematic cells of the growth cone. The energy separated out during the process of breathing is dissipated, apparently, not only on the assimilation of mineral elements of feeding and the synthesis of organic compounds but also on the lowering of the toxic effects of the herbicides which enter the cells of the vegetable organism. Therefore, the productivity of the hemp plant in the indicated variant is lowered. Evidence of this is given by the yield data for 1961 - 1963 (Table 4).

Table 4

Variants	Yield in Centners per Hectare			Variants	Yield in Centners per Hectare		
	Of Seeds	Of Dry Stems	Of Fibre		Of Seeds	Of Dry Stems	Of Fibre
Control (usual amount)	9,5	42,9	7,8	Atrazine 1,5	9,0	42,7	7,9
Simazine 1,0	9,3	43,7	8,0	" 2,0	8,6	40,3	7,2
" 1,5	9,1	43,4	7,8	" 3,0	6.9	33,5	6,1
" 2,0	8,6	40,8	7,3	Error of Average Yields in Centners per Hectare	0,32	0,85	-
" 3,0	7,3	35,1	6,4	Accuracy of Test in %	4,06	2,25	-
Atrazine 1,0	9,1	44,1	8,2				

A lowering in the hemp yield is a result of rupture in the process of root feeding and suppression by herbicides of the synthesis of organic compounds. Therefore, in the struggle against weeds in seed growing plantings of hemp when the soil is dark gray medium loam, the doses of simazine and atrazine should not be greater than 1 -- 1.5 kilograms of active substance per hectare.

Conclusions. Triazine compounds -- simazine and atrazine in doses of up to two kilograms per hectare don't have any effect on physiological processes in hemp plants, however, doses of two kilograms per hectare and over have unfavorable effects of these processes.

Under the influence of toxic action by atrazine and simazine there occurs weakening in the process of breathing and synthesis of organic compounds in the hemp leaves is suppressed; the carbohydrate-protein exchange is disrupted and there is a noticeable lowering in the uptake of mineral nutrient elements --nitrogen, phosphorous, and potassium -- in the hemp plants.

The listed physiological disruptions lead to a lowering of the productivity of the plants and a lowering in the yield of hemp stems, seeds, and fibres.

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Submitted to the Editors
27 August 1964